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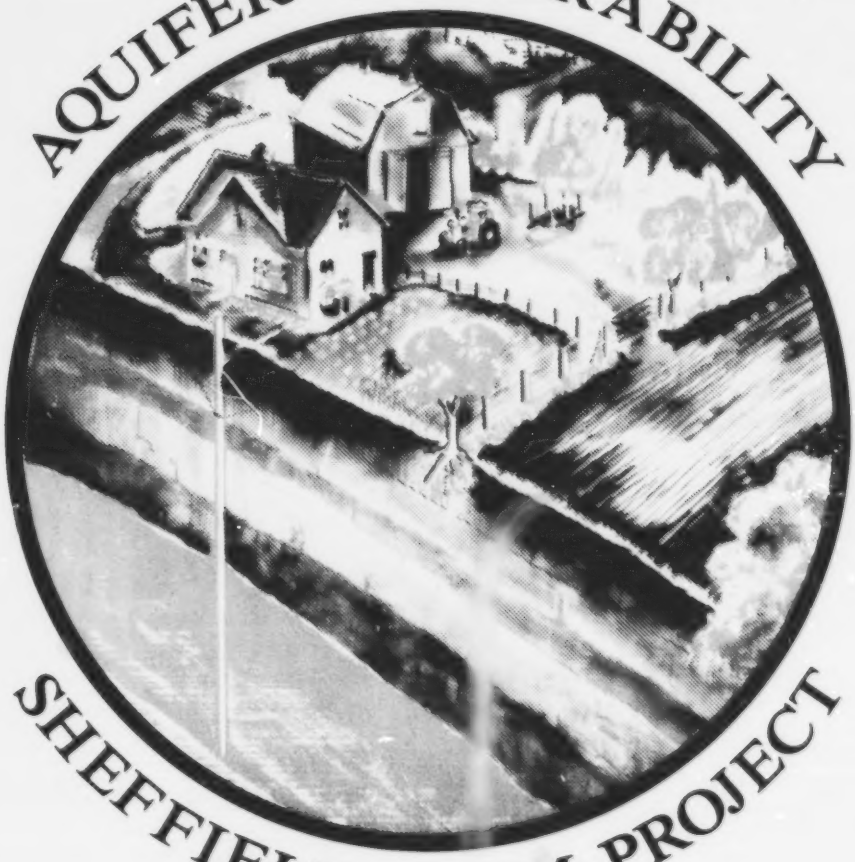

SHEFFIELD FARM PROJECT

YEAR ONE (1988/89) REPORT

CONSERVATION & PROTECTION

INLAND WATERS DIRECTORATE
ATLANTIC REGION
WATER PLANNING AND MANAGEMENT BRANCH
DARTMOUTH, NOVA SCOTIA

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AQUIFER VULNERABILITY

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YEAR ONE (1988/89) REPORT

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Inland Waters Directorate
Conservation & Protection
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Executive Summary

During the 1988/89 field season, reconnaissance hydrogeological studies were carried out on the Sheffield Farm. These included detailed coring of the soil materials and bedrock, split spoon sampling, installation of nineteen 5-cm diameter piezometers in the completed boreholes, a limited number of hydraulic tests and some ground and surface water sampling. Piezometer development, using air lift combined with groundwater from the site, was approximately eighty percent completed.

Ongoing work plans include the development of a computerized data base, spatial analysis of the data, the completion of piezometer development and water sampling and analysis, hydraulic conductivity testing, surface water hydrometrics including tile drain effluent emanating from a neighbouring farm, terrain and borehole geophysics, the updating of soils maps, surficial and bedrock geology and land use. Much of this work is being co-ordinated with the Centre for Water Resources Studies of the Technical University of Nova Scotia in Halifax, the National Hydrology Research Institute, Saskatoon, Saskatchewan, the National Water Research Institute, Burlington, Ontario and the Environmental Chemistry Laboratory, Victoria General Hospital, Halifax, Nova Scotia.

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1.0 INTRODUCTION

The Memorandum of Understanding between Agriculture Canada and Environment Canada signed on September 8, 1988 formalized the Aquifer Vulnerability - Sheffield Farm Project.

The five year project is divided into two phases. Phase I, during the 1988 to 1990 period, is to characterize the experimental site and to design specific experiments. Phase II, the three years including 1990 until 1993, are for the implementation of experiments, effects monitoring, followed by interpretation and publication of the findings.

This report is on the year one activities. Year one is the 1988/89 fiscal year even though the formal MOU was not signed until half way through the year. In spite of the late MOU signing a number of activities were undertaken and completed in 88/89. This report documents the development of monitoring piezometers and presents some early findings. Thoughts on future experiments and details on equipment acquired to date are also documented.

2.0 FIELD ACTIVITIES

2.1 Piezometers - Placement and Construction

The location of the Sheffield Farm within Nova Scotia is shown in figure 1 while figure 2 shows the Farm location within the Annapolis Valley. Three field sites were chosen, based on available data for pesticide-nitrate application experiments. The fields A, B and C, are shown in figure 3. One other site, field D, was specifically chosen for the monitoring of possible off-site influences from a neighbouring high bush blueberry operation.

During August and September of 1988, reconnaissance hydrogeological studies were carried out in the areas identified above. A track mounted solid stem auger equipped for overburden soil sampling and bedrock coring was used to drill nineteen boreholes and collect overburden/bedrock samples. A total of twelve boreholes were finished in the overburden, while the remaining seven were completed in bedrock.

In the boreholes, 5 cm diameter, schedule 40, PVC piezometers with No. 30 slot PVC screens (well points) were installed. The well points were gravel packed (sand or gravel) with 64mm (0.25 in.) silica sand. Bentonite was used to grout each piezometer above the sand pack and a combination of bentonite and native material was used to backfill the annulus of the boreholes to prevent surface water entry into the piezometers. The sand pack was extended above the screen so that the bentonite seal could not settle and clog the screens.

Extentions were added to nine of the standpipes considered to be too short for farm vehicle operators to see while working. Figure 4 shows all piezometers including the extended piezometers A2, A5, A6, B5, B6, C3, C4, D2 and D3. The bottom sections of these standpipes were not threaded and could not be flush jointed. Piezometers B5, C3 and D2 were flowing artesian and therefore required watertight seals to stop groundwater leakage from around their joints.

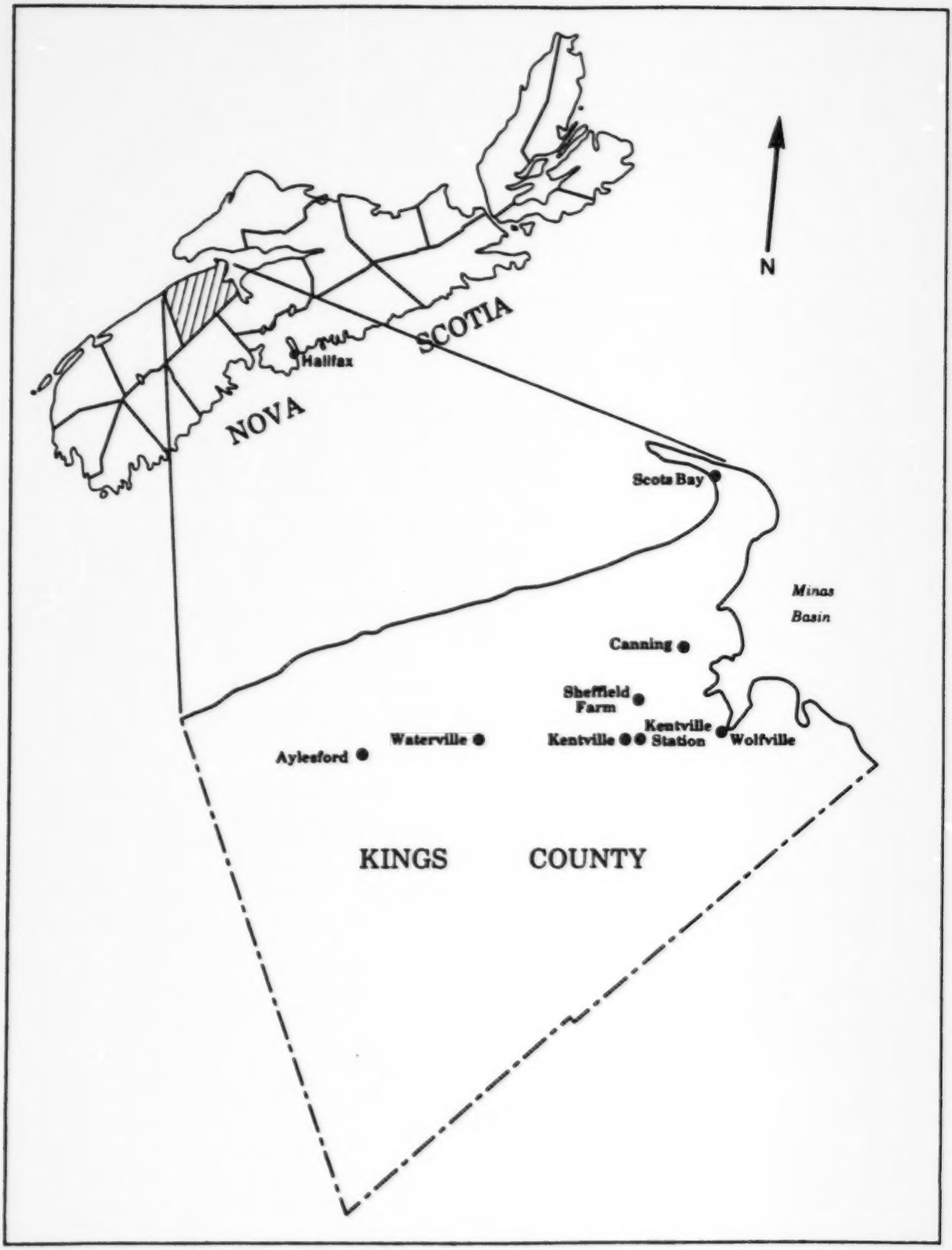

FIG. 1 GENERAL LOCATIONS OF THE KENTVILLE RESEARCH STATION AND SHEFFIELD FARM.

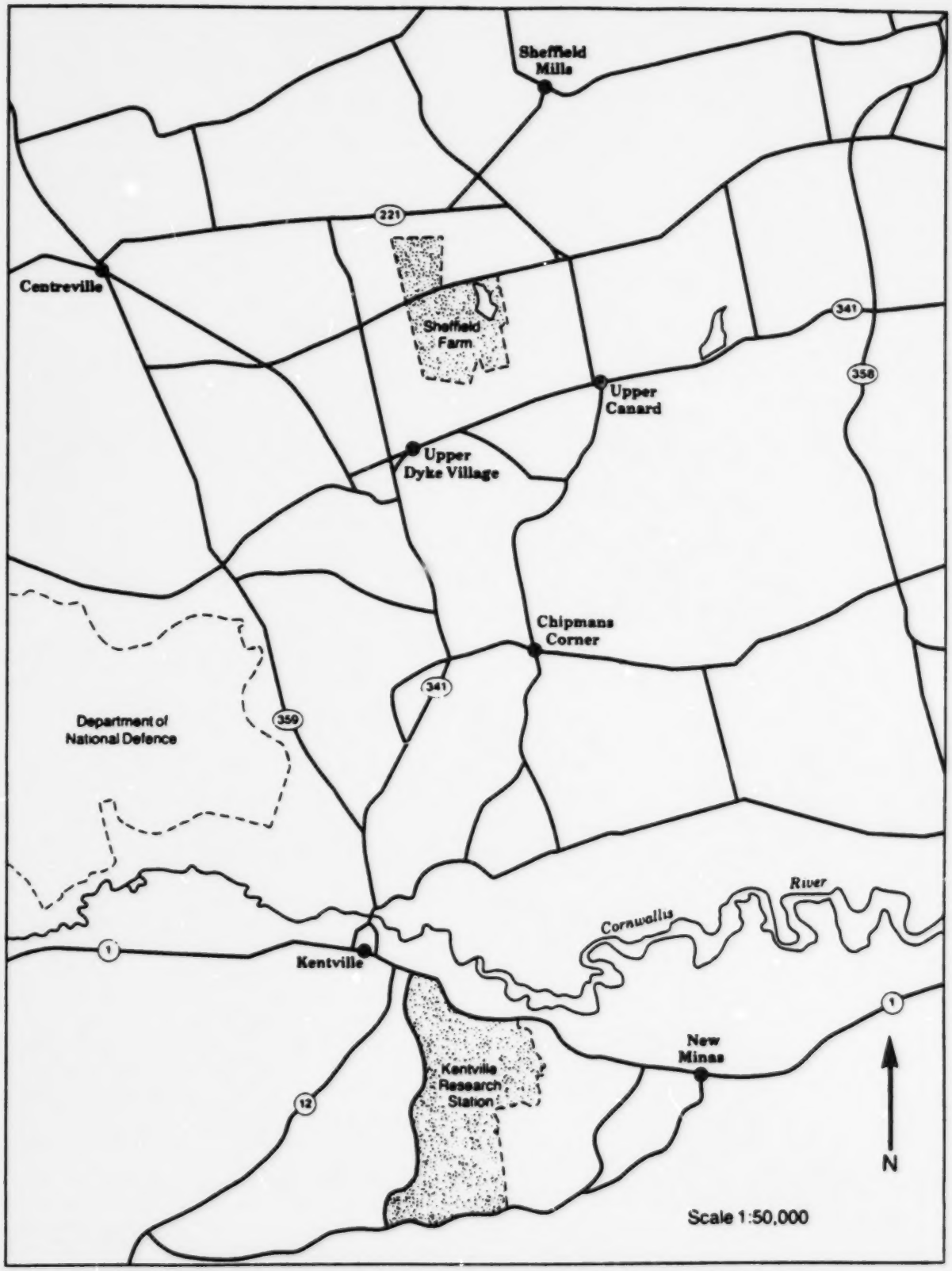

FIG. 2 LOCATION OF KENTVILLE RESEARCH STATION AND SHEFFIELD FARM.

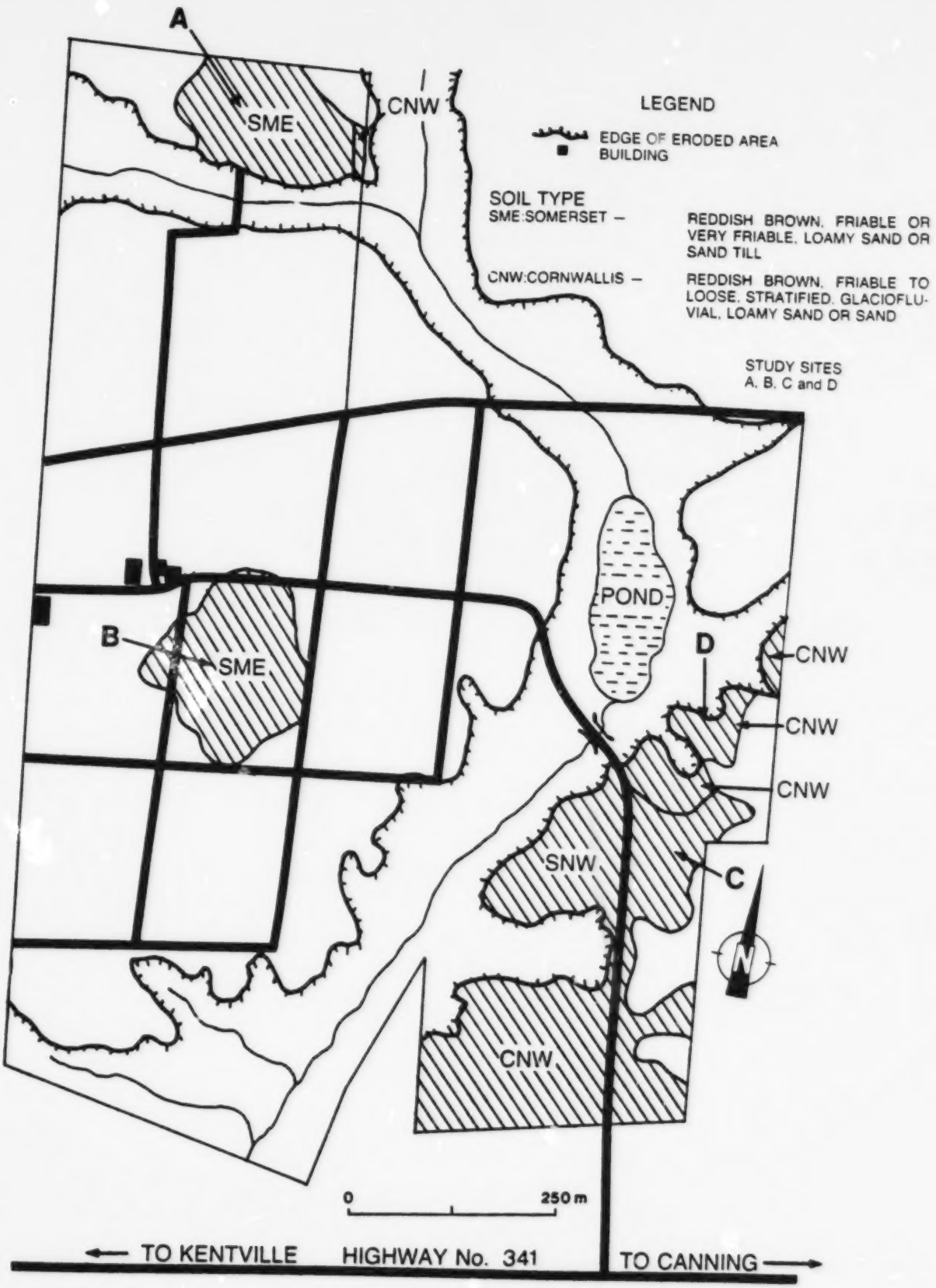

FIG. 3 SHEFFIELD FARM STUDY SITES

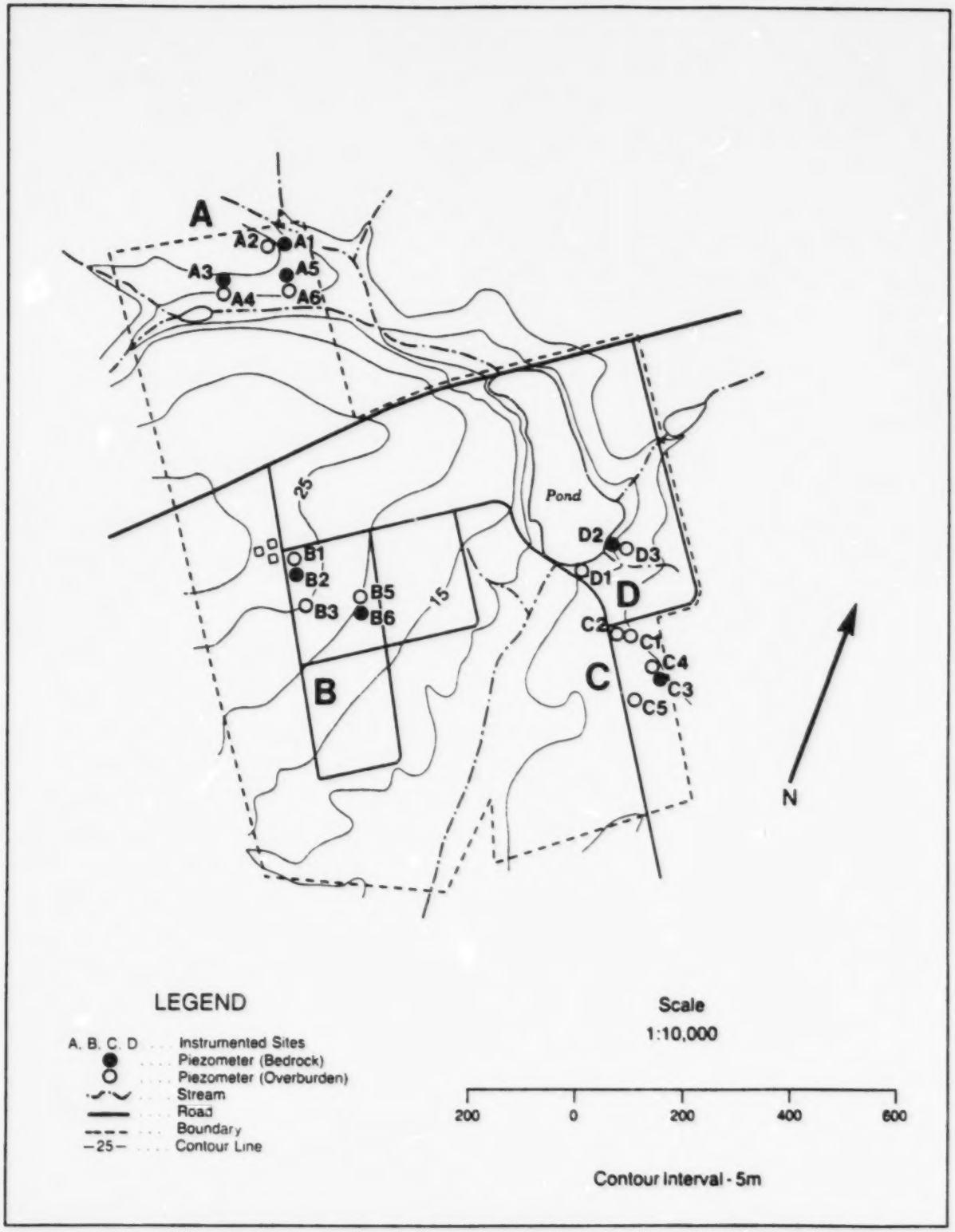

FIG. 4 SHEFFIELD FARM – SHEFFIELD MILLS (NOVA SCOTIA) PIEZOMETER LOCATIONS.

A second larger diameter outside casing was placed around these piezometers and cement grouted into place. This measure should keep the standpipe extensions in a permanent position and maintain a watertight seal.

The piezometers were constructed without glue, with sections joined with threaded couplings, because the solvent in PVC glue has been shown to contribute significant quantities of various organic compounds to the water. Figure 5 shows a typical piezometer construction cross-section.

Vertical gradients and chemical stratification can only be determined with multiple-level piezometer nests. Therefore, shallow and deep piezometers were installed in eight different locations. The nests consist of piezometers installed in two holes adjacent to each other. Seven of the nests include an overburden and a bedrock well. One nest has two wells completed in overburden and there are three single piezometers finished in overburden. Overburden piezometers have depths ranging from 2.92m to 14.84m (9 ft. 7 in. to 48 ft. 8 in.) and the bedrock wells have depths ranging from 7.29 to 23.90 metres (23 ft. 11 in. to 78 ft. 5 in.). The monitoring wells were placed so that triangulation of the water tables and piezometer surfaces can be accommodated.

2.2 Borehole Logging and Sampling

Geological sampling via split spoon provided relatively undisturbed samples for on-site inspection, description and logging. The samples also provide a medium for calibrating borehole geophysics and for identifying minor stratigraphic changes important to contaminant flow. The samples were sent to the National Water Research Institute (NWRI), Burlington, for particle-size distribution analysis.

However, due to time and budgetary constraints, the split spooning of several boreholes was done less frequently or not at all. Although auger sampling does not yield very high resolution results, this method was used in boreholes adjacent to ones that had already been sampled by the split spoon method. This procedure allowed the drilling and piezometer emplacement to proceed more quickly while still maintaining good sampling control of geological materials.

Results of thirteen out of 65 sieve and sedigraph analyses are presented in Table 1. To date, thirteen of the 65 overburden samples collected have been analysed for grain-size distribution. In order to increase efficiency, only the remaining split spoon samples will be analysed for grain size distribution. It is important to note that the resulting grain size analyses received thus far compare very well with the on-site logging results.

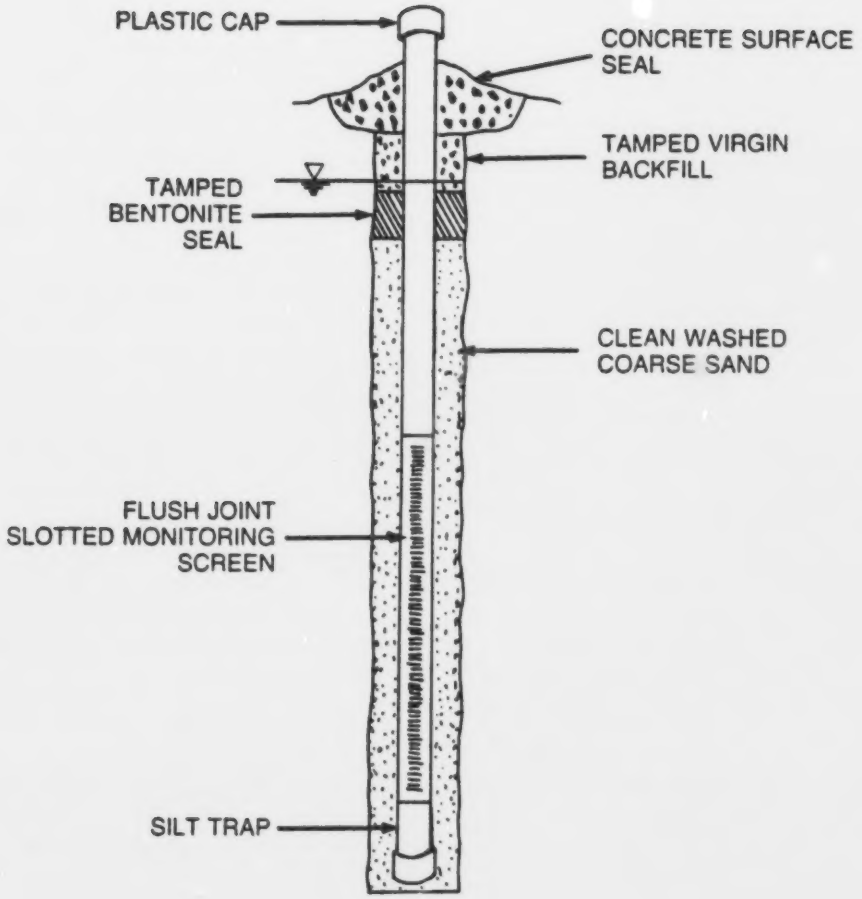

FIG. 5 TYPICAL PIEZOMETER CONSTRUCTION.

Table 1

Sieve and Sedigraph Analyses from

Sheffield Farm Boreholes

Piezometer Number	Depth of Sample(Metres)	Gravel %	Sand %	Silt %	Clay %
A5	3.2	1.16	59.96	17.07	21.81
	7.0	0.68	50.07	26.62	22.64
B2	2.3	1.67	45.52	23.88	28.93
	9.2	11.91	72.14	6.29	9.65
B6	3.1	6.89	60.47	11.69	20.95
	10.7	4.91	76.86	10.67	7.56
C1	3.3	11.96	79.03	4.54	4.46
	12.9	3.61	51.47	30.25	14.67
C3(NEW)	0.8	3.13	66.28	10.98	19.62
	2.3	0.10	64.36	23.27	12.27
	19.1	15.95	61.20	15.44	7.41
D2	0.8	0.62	63.14	19.43	16.82
	6.9	3.60	66.23	10.87	19.29

Grain size-analysis were performed using the procedures of Duncan and LaHaie, 1979.

Diamond coring was used to collect bedrock samples. In some instances the recovery of bedrock materials was poor or nonexistent. However, enough bedrock cores have been collected to confirm what is already known from the geological literature. Total core recovery was approximately five metres.

Additional soil sampling was carried out in field 'A' which corresponds to Agriculture Canada's field B1. A hand auger was used to drill 30 one-metre deep boreholes in a grid pattern covering an area of 6000 m^2. The grid included augering points at 20 metre intervals along east-vest lines and 15 metre intervals along lines in the north-south direction. Each auger hole was sampled at 20 cm intervals, therefore 150 soil samples were collected. The soils have not been analysed for grain size distribution. However, most of the equipment needed to do this work has been purchased. Both the equipment and the soils have been stored until the need for more detailed grain size distribution analyses is evaluated. The need may be in connection with groundwater model development, particularly modelling in the unsaturated zone.

Results of the organic carbon analysis are provided in Table 2. The analysis were conducted by NWRI at the University of Waterloo.

2.3 Piezometer Development

Piezometer development was carried out to remove fine grained material in the gravel pack and adjacent formation that could clog the screen or cause turbidity in the water samples. This was done on an ongoing basis throughout the summer of 1988. Four types of pumps were used in developing the piezometers, including a peristaltic (rotary) pump, a construction (gravity) pump, a submersible pump driven by compressed air, and a Wattera (hand operated inertia-lift pump). Their effectiveness in removing silt and sand from around the piezometer screens was limited by the large initial volumes of sediments being purged and a lack of available drawdown in the shallow piezometers. The progress made in developing the piezometers was therefore very slow. This is not unusual particularly in piezometers in till. It was decided to employ an air-lift development system that would at least hasten the development process in the deeper piezometers and purge the heavier grain sized fractions from the shallower piezometers.

TABLE 2

ORGANIC CARBON CONTENT OF SELECTED

SOIL SAMPLES AT SHEFFIELD FARM

SAMPLE	DATE	ORIG. WT. + TUBE	WT. - CO3 + TUBE	WT.TUBE	WT.ANAL.	FOC(%) RAW	FOC(%) RCF	FOC(%) TOTAL	
SF1	24/01/89	26.835	26.711	19.812	0.751	0.000	0.000	0.000	SFA5 (3.2 m)
SF2	26/01/89	28.917	28.843	21.274	0.947	0.023	0.019	0.019	SFB2 (9.2 m)
SF3	26/01/89	25.046	24.913	19.781	0.886	0.014	0.013	0.012	SFB6 (9.2 m)
SF4	24/01/89	28.389	28.276	19.800	0.900	0.068	0.060	0.060	SFL6 (0.8 m)
SF5	24/01/89	28.900	28.819	21.385	1.221	0.036	0.024	0.023	SFC3 (new) (2.3 m)
SF6	24/01/89	28.968	28.694	21.290	0.876	0.025	0.023	0.022	SFD2 (6.9 m)

An 8-horsepower (14.4 CFM, 100 PSI) gas driven double tank compressor with attachments (air line and inductor pipe) was used to purge sediment-laden groundwater from the piezometers. This method proved effective provided there was sufficient groundwater recharge to replace the water being purged. The shallow monitoring wells were quickly purged and allowed to recharge, sometimes overnight, while the more productive monitoring wells were being developed. The optimum purging pressure was found to be 40 PSI. At this rate, the piezometers with sufficient groundwater recovery could be purged at relatively constant rates.

The development status by the first week in September 1988, was as follows: piezometers B6, C1 and C3 were fully developed, piezometers A1, B3, B5, C2, C4, C5 and D2 were still needing development work, and piezometer D appeared to be worsening, which was likely due to a break in the base of the well point. A "plug" specifically designed to repair such breaks will be installed in April or May, 1989.

Several containers of groundwater, obtained from the Sheffield Farm domestic well, were used along with compressed air (air-lift) in order to hasten the development in the shallow piezometers. The addition of water appeared to work, however it was time-consuming to bring the water by the bucket or barrel to the piezometer sites. Between August 7 and September 7, '88 approximately 10 hours of development time had been spent on each piezometer.

The cost for hiring a water truck with driver was prohibitive, therefore in October 1988 a water tanker was acquired to be used in conjunction with the air-lift system for piezometer development. Two other cost effective options were investigated, a town of Kentville fire truck and a privately owned water tanker. The fire truck option had two major flaws: the fire department wanted to use town water which is chlorinated and, moreover, a petroleum based product is added to their pumpers to prevent corrosion and as a spray dispersant. The privately owned water tanker was found to have petroleum product in it. A suitable water tanker, made from stainless steel and attached to a four-wheeled farm trailer, was located and subsequently loaned for use on the Sheffield Farm. The farm tractors used by Agriculture Canada were made available for hauling the water tanker to and from the piezometers being developed. Water was pumped into the tanker from the farm well and syphoned off during the development process. Approximately 50,000 litres of groundwater were used to develop the 16 piezometers. An average of 3000 litres of water and 6 to 8 hours of air-lift development time were devoted to each piezometer installation during the November work period. Further work is still required prior to groundwater sampling in the spring of 1989.

2.4 Slug Testing

Hydraulic tests (slug tests) were carried out in six piezometers (A3, B1, C1, C2, C3 and C5) and two in C2 and C5. The hydraulic head data collected in piezometers A3, B1 and C1 were obtained manually. In piezometers C2, C3 and C5 data were collected using a pressure transducer and data recording system. However, the battery power source for this equipment failed and the entire unit had to be sent to the U.S. manufacturer for replacement. Groundwater velocities, as determined by the Hvorslev (1951) method, ranged between 10^{-4} and 10^{-6} m/s. All 19 piezometers should be retested using the data acquisition method described below.

Prior to carrying out the slug tests, static water levels were measured with an electric tape. An inflatable packer was then installed 0.5 to 1.0 metre below the water table. The data logger, an SE-100 Hydraulic Monitor, was initialized and the piezometer filled with water to the top of the casing. A pressure transducer was placed just above the packer. The packer unit was quickly deflated and 10 falling head measurements were recorded within the first second of the test. Excellent reproductibility of calculated hydraulic conductivities can be achieved using these procedures.

2.5 Water Chemistry

Staff from the Water Quality Branch, IW, Moncton, N.B., assisted with the collection of nine water samples on November 24, 1988. The water samples were analysed for inorganic chemistry. Included in the sampling were seven groundwater samples from piezometers and the farm well. Two surface water samples including the tile drainage from the adjacent blueberry operation and the pond outlet were taken. The results for nitrate are given in Table 3.

TABLE 3

NITRATE AND NITRITE VALUES AT SELECTED SAMPLING POINTS

SAMPLING POINT	NITRATE + NITRITE (mg/l)
piezometer A1	0.8
piezometer A2	0.04
piezometer A4	4.6
piezometer A5	9.2
piezometer A6	5.0
piezometer B1	11.0
farm well	9.2
tile drainage	4.1
pond outlet	4.7

2.6 Surveying

The elevation of each piezometer stand pipe was surveyed relative to monument #8179. Transit Bench Mark #1 is the NW corner of the cement footing of the Sheffield Farm sign. It is the footing closest to the road at the entrance to the farmhouse driveway. The piezometer standpipe elevations will be surveyed again in 1989. Adjustments can then be made to account for any errors or discrepancies that may exist.

2.7 Water Levels

Seventeen rounds of water level measurements were obtained during the period from August 12 to September 14, 1988. Water level readings were converted to measurements of hydraulic head and are reported in metres above mean annual sea level. Arrangements will be made to obtain the services of someone to routinely collect water level data during the 89/90 field season.

3.0 ONGOING ACTIVITIES

3.1 Data Management

Since January 1989, the Water Planning and Management Branch, Inland Waters Directorate, Atlantic, has been investigating the potential usefulness of a geographic information system (GIS) to facilitate hydrogeological data analyses and presentation. A graduate student from the Technical University of Nova Scotia (TUNS) is presently determining the suitability of SPANS (Spatial Analysis System) for this purpose. The data being generated from this study will be applied to a SPANS format and a program for groundwater data management will be developed. Classifying and categorizing of spatial data for input into the system and for the later integration of thematic, topographic and planemetric maps is ongoing. The uniqueness of this project is not in the strict spatial analysis of geographical information, but rather the integration of disseminated information used in groundwater studies.

Future elements of the data base management system will include data input from the farm site via a portable terminal, digital data storage and retrieval, statistical analyses and graphical outputs, groundwater flow modelling and computer aided drafting. Data types, locations and formats are given in Table 4.

TABLE 4

DATA COVERAGE AND SOURCES

Data	Source	Format
1. Piezometer locations, logs and elevations	Water Planning & Management Branch	Input to database
2. Hydraulic	Water Planning & Management Branch	Input to database
3. Piezometer Soils Sieve Analysis	National Water Research Institute	Digital
4. Soils Map(s)	Agriculture Canada	Digital (in process)
5. Topography	Land Registration and Information Service	Digital
6. Climatological	Atmospheric Environment Service	Digital
7. Water Chemistry	Water Quality Branch	Digital
8. Bedrock	Nova Scotia Department of Mines and Energy	Paper
	Water Planning & Management Branch	Paper

4.0 EQUIPMENT

The conduct of the Aquifer Vulnerability Study requires special equipment which is not available on loan from other agencies (e.g. NWRI) on the long-term basis needed. The equipment purchased in 88/89 by the Water Planning and Management Branch to overcome those deficiencies are presented in Table 5 shown below.

TABLE 5

EQUIPMENT PURCHASED

1	YSI 3560 Water Quality Monitoring System
1	Model XP 100-60 (Expendable Purge and Sampling) Mini Pump System, with dry run protection.
1	Twin tank air compressor - portable Sanborn Model 5 h.p. gasoline driven Honda motor.
1	A-200R Type "A" Grout Plug (to repair damaged piezometer)
1	Water Level Indicator - Standard model #101 (100 ft; flat tape)
1	Waterra inertia-lift hand pump (Stainless Steel Levered Pump), foot valves and tubing.

5.0 SUMMARY

During the 1988/89 field season, reconnaissance hydrogeological studies were carried out on the Sheffield Farm. These included piezometer placement and detailed coring of the soil materials and bedrock, split spoon sampling, installation of nineteen 5-cm piezometers with well points in the completed boreholes, eight slug tests, and nine cursory ground and surface water samples analyzed for inorganics. The piezometer development, using an air lift technique was approximately eighty percent completed in 88/89.

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